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Table 4-1a
Identification and Technical Implementability Screening of Potentially Applicable Remedial Technologies/Process Options
Contaminated Soil

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
No Action	None	None	No action would be taken. Contaminated soil would remain in its existing condition.	Required by NCP as baseline for comparison.	Yes
Monitoring	Inspection	Non-Intrusive Visual Inspection	A non-intrusive (surficial) visual inspection of the immediate ground surface to determine the presence or absence of indicators for Libby Amphibole (LA) asbestos contamination, such as vermiculite, within contaminated soil.	Potentially implementable process option.	Yes
		Intrusive Visual Inspection	An intrusive visual inspection of the subsurface (using excavations or boreholes) to determine the presence or absence of indicators for LA asbestos contamination, such as vermiculite, within contaminated soil.	Potentially implementable process option.	Yes
	Sampling and Analysis	Sample Collection and Microscopic Analysis	Air and/or soil samples would be collected for microscopic analysis in a laboratory to determine the potential presence of LA asbestos fibers. Types of samples collected include but are not limited to soil, ambient air, and ABS. Types of microscopic analyses include but are not limited to PLM, stereomicroscopy, and TEM.	Potentially implementable process option.	Yes
Administrative Controls	Institutional Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with contaminated soil would be controlled through legal instruments. Examples of governmental (state or local) controls include but are not limited to zoning restrictions, permits, codes, statutes, regulations, and ordinances. Examples of proprietary controls include but are not limited to instruments such as easements and covenants. Examples of informational devices include but are not limited to state registries of contaminated properties, deed notices, and advisories.	Potentially implementable process option.	Yes
	Community Awareness Activities	Information and Education Programs	Community information and education programs would be undertaken to enhance awareness of potential hazards and remedies for contaminated soil. An example of a community information and education program includes the Environmental Resource Specialist (ERS) program.	Potentially implementable process option.	Yes
		Notification Programs	Notification programs would be undertaken to inform the community of potential hazards from contaminated soil at specific locations. Examples of notification programs include the "U-Dig" system typically used for utility location.	Potentially implementable process option.	Yes

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Table 4-1a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Access Controls	Access Restrictions	Fencing and/or Posted Warnings	Contaminated soil would be enclosed by fences and warning signs to control access by human receptors and some ecological receptors.	Potentially implementable process option.	Yes
Relocation	Temporary Relocation	Temporary Relocation of Residents	Residents would be temporarily relocated to minimize exposure to LA asbestos during implementation of other GRAs.	Potentially implementable process option.	Yes
	Permanent Relocation	Permanent Relocation of Residents	Residents would be permanently relocated to eliminate exposure to LA asbestos.	Potentially implementable process option.	Yes
Containment	Surface Source Controls	Water-Based Suppression	Contaminated soil would be kept “adequately wet” using water or a water-based dust suppressant to control airborne migration of LA asbestos fibers from contaminated soil to the surrounding environment.	Potentially implementable process option.	Yes
		Chemical-Based Suppression	Contaminated soil would be treated with a resinous or petroleum-based chemical dust suppressant to control airborne migration of LA asbestos fibers from contaminated soil to the surrounding environment.	Potentially implementable process option.	Yes
		Negative Pressure Enclosures	Contaminated soils would be enclosed within a temporary structure. The structure would be operated under negative pressure with filtering to control airborne migration of asbestos fibers in dust to the surrounding environment.	Potentially implementable process option.	Yes
		In Situ Mixing	Contaminated soil would be mixed with underlying uncontaminated soil or fill materials.	Potentially implementable process option.	Yes
		Soil or Rock Exposure Barrier/Cover	Contaminated soil would be covered with a layer of clean soil or rock with sufficient thickness to eliminate surface exposure of contaminated soil.	Potentially implementable process option.	Yes
		Asphalt or Concrete Exposure Barrier/Cover	Contaminated soil would be covered with layers of asphalt or concrete with sufficient thickness to eliminate surface exposure of contaminated soil.	Potentially implementable process option.	Yes
		Geosynthetic Multi-Layer Exposure Barrier/Cover	Contaminated soil would be covered with geosynthetic material (such as geomembrane or a geosynthetic clay liner [GCL]) along with protective vegetative or rock layers to eliminate surface exposure of contaminated soil.	Potentially implementable process option.	Yes

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Table 4-1a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Removal, Transport, Disposal	Removal	Mechanical Excavation (Excavation)	Contaminated soil would be removed using mechanical excavation methods.	Potentially implementable process option.	Yes
		Pneumatic Excavation (Vacuum Extraction/Pumping)	Contaminated soil would be excavated using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	Potentially implementable process option.	Yes
	Transport	Mechanical Transport (Hauling/Conveying)	Contaminated soil would be transported by truck or other mechanical conveyance method to disposal site.	Potentially implementable process option.	Yes
		Hydraulic Transport (Slurry Pumping)	Contaminated soil would be transported in slurry form using a pipeline or other hydraulic conveyance system to disposal site.	Potentially implementable process option.	Yes
		Pneumatic Transport (Vacuum Extraction/ Pumping)	Contaminated soil would be transported using vacuum hoses, vacuum trucks, or other pneumatic conveyance system to disposal site.	Potentially implementable process option.	Yes
	Disposal	Landfill Disposal	Removed contaminated soil would be disposed of at a landfill facility authorized for disposal of asbestos.	Potentially implementable process option.	Yes
		Mine Disposal	Removed contaminated soil would be disposed of at the Former Libby Asbestos Vermiculite Mine.	Potentially implementable process option.	Yes
		Subaqueous Disposal	Removed contaminated soil would be disposed of within an impoundment or other large body of water.	Potentially implementable process option.	Yes

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Table 4-1a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Treatment	Biological Treatment	Vermiprocess	Worms are employed to convert contaminated soil into an inert waste material.	Not technically feasible for site application because it has not been demonstrated for large-scale remediation of asbestos in contaminated soil.	No
		Phytoremediation	LA asbestos in contaminated soil would be treated/removed using select plant species.	Not technically feasible for site application because no plant has been identified that can remove asbestos from contaminated soil through phytoremediation.	No
	Chemical and/or Physical Treatment	Pozzolan- or Cement-Based Ex Situ Stabilization/Solidification	Contaminated soil would be mixed ex situ with a pozzolan- or cement-based binding agent before disposal.	Potentially implementable process option.	Yes
		Pozzolan- or Cement-Based In Situ Stabilization/Solidification	Contaminated soil would be mixed in situ with a pozzolan- or cement-based binding agent using a deep soil auger mixing/injection technique.	Potentially implementable process option.	Yes
		Chemical Decomposition	LA asbestos in contaminated soil would be decomposed to an amorphous silica suspension at relatively low temperatures (~100°C) using chemicals tailored to the waste stream. The resulting amorphous silica would then be solidified for disposal as an inert waste. ABCOV™ is a demonstrated form of this technology.	Potentially implementable process option.	Yes
		Chemical Digestion	Contaminated soil would be treated using a spray-applied foam that soaks into porous materials and converts asbestos contained within to an inert, non-fibrous form. DMA® is a commercial form of this technology.	Not technically feasible for site application because the technology has only been demonstrated to affect chrysotile asbestos-containing porous materials that can readily absorb the digestion agent and has not been specifically identified or demonstrated to affect amphibole asbestos.	No
		Soil Washing	Contaminated soil would be flushed with a site-specific washing solution; flushed LA asbestos would be collected for further treatment and/or disposal.	Not technically feasible for site application because it has not been specifically identified or demonstrated for remediation of asbestos contaminated soil.	No
		Soil Flushing	A washing solution (as with soil washing) would be circulated through contaminated soil with the use of injection and extraction wells or trenches; flushed LA asbestos would be collected for further treatment and/or disposal.	Not technically feasible for site application because it has not been specifically identified or demonstrated for remediation of asbestos contaminated soil.	No
	Thermal Treatment	In Situ Vitrification	An electrical current would be passed between electrodes inserted into in-place contaminated soil to cause melting. The melted matrix is then allowed to cool in place into a solid vitrified glass mass.	Potentially implementable process option.	Yes

Comment [glh1]: CDM Smith still needs to confirm that DMA does not affect amphibole asbestos.

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Table 4-1a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Treatment – Continued	Thermal Treatment – Continued	Electric Arc Vitrification (Ex Situ)	An electrical current would be passed between electrodes in a furnace creating an electrical arc. Contaminated soil placed in the furnace form a molten bath that cools to form a vitrified glass mass. The vitrified glass mass is an inert waste.	Potentially implementable process option.	Yes
		Plasma Arc Vitrification (Ex Situ)	An electrical current would be passed between electrodes to form plasma. Contaminated soil placed in the plasma arc form a molten bath that cools to form a vitrified glass mass. The vitrified glass mass is an inert waste.	Potentially implementable process option.	Yes
		Incineration (Ex Situ)	Contaminated soil would be crushed and mixed. The mixture is subjected to incineration without chemical additives. The reaction product is an inert waste.	Not technically feasible for site application because it has not been specifically identified or demonstrated for remediation of LA asbestos in contaminated soil.	No
	Thermal/Chemical Treatment	Thermo-Caustic Dissolution	Contaminated soil would be placed into a high temperature caustic (strong basic) solution. Asbestos fibers are partially to fully converted (changed to an amorphous structure) during immersion. Partially converted asbestos fibers are further converted using chemical reactions to form a viscous mixture, which is later vitrified. The resulting reaction product (glass) is an amorphous inert waste.	Potentially implementable process option.	Yes
		Thermo-Chemical Treatment	Contaminated soil would be mixed with proprietary fluxing agents. The mixture is then heated in a rotary hearth furnace. This process is similar to vitrification but does not involve complete melting. The presence of the fluxing agents at elevated temperatures results in remineralization of asbestos fibers. The fibers are converted into non-asbestos minerals such as diopside, olivine and glass.	Potentially implementable process option.	Yes

Notes:

1. The screening process for technical implementability involves a qualitative assessment of the degree to which process options address evaluation criteria presented in Section 4.5.
2. Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of technical implementability. Remaining (unshaded) remedial technologies/process options have been retained for additional screening in Table 4-2a.

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Table 4-1b
Identification and Technical Implementability Screening of Potentially Applicable Remedial Technologies/Process Options
Vermiculite Containing Building Materials

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
No Action	None	None	No action would be taken. Vermiculite containing building materials would remain in their existing conditions.	Required by NCP as baseline for comparison.	Yes
Monitoring	Inspection	Non-Intrusive Visual Inspection	A non-intrusive visual inspection of the structure/building to determine the presence or absence of indicators for Libby Amphibole (LA) asbestos contamination, such as vermiculite, within building materials.	Potentially implementable process option.	Yes
		Intrusive Visual Inspection	An intrusive visual inspection of the structure/building (using drill and/or scope) to determine the presence or absence of indicators of LA asbestos contamination, such as vermiculite, within building materials.	Potentially implementable process option.	Yes
	Sampling and Analysis	Sample Collection and Microscopic Analysis	Air, dust, and/or bulk building material samples would be collected for microscopic analysis in a laboratory to determine the potential presence of LA asbestos fibers. Types of samples collected include but are not limited to bulk building materials, dust, ambient air, and ABS. Types of microscopic analyses include but are not limited to PLM, stereomicroscopy, and TEM.	Potentially implementable process option.	Yes
Administrative Controls	Institutional Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with vermiculite containing building materials would be controlled through legal instruments. Examples of governmental (state or local) controls include but are not limited to zoning restrictions, permits, codes, statutes, regulations, and ordinances. Examples of proprietary controls include but are not limited to instruments such as easements and covenants. Examples of informational devices include but are not limited to state registries of contaminated properties, deed notices, and advisories.	Potentially implementable process option.	Yes
	Community Awareness	Information and Education Programs	Community information and education programs would be undertaken to enhance awareness of potential hazards and remedies for vermiculite containing building materials. An example of a community information and education program includes the Environmental Resources Specialist (ERS) program.	Potentially implementable process option.	Yes
		Notification Programs	Notification programs would be undertaken to inform the community of potential hazards from vermiculite containing building materials at specified locations.	Potentially implementable process option	Yes

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Table 4-1b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Access Controls	Access Restrictions	Posted Warnings	Warning signs would be used to warn people of dangers posed by vermiculite containing building materials.	Potentially implementable process option.	Yes
Relocation	Temporary Relocation	Temporary Relocation of Residents	Residents would be temporarily relocated to minimize exposure to LA asbestos during implementation of other GRAs.	Potentially implementable process option	Yes
	Permanent Relocation	Permanent Relocation of Residents	Residents would be permanently relocated to eliminate exposure to LA asbestos.	Potentially implementable process option	Yes
Containment	Surface Source Controls	Water-Based Suppression	Vermiculite containing building materials would be kept “adequately wet” using water or a water-based dust suppressant to control airborne migration of LA asbestos to the surrounding environment.	Potentially implementable process option.	Yes
		Chemical-Based Suppression	Vermiculite containing building materials would be treated with a resinous or petroleum-based chemical dust suppressant to control airborne migration of LA asbestos fibers from contaminated soil to the surrounding environment.	Potentially implementable process option.	Yes
		Encapsulation	Vermiculite containing building materials would be sealed and covered with high performance coating to prevent the release of LA asbestos fiber under foreseeable conditions, such as impact, age degradation, or vibration.	Potentially implementable process option.	Yes
		Negative Pressure Enclosures	Vermiculite containing building materials would be enclosed within a temporary structure. The structure would be operated under negative pressure with filtering to control airborne migration of LA asbestos fibers in dust to the surrounding environment.	Potentially implementable process option.	Yes
Removal, Transport, Disposal	Removal	Mechanical Excavation	Vermiculite containing building materials would be removed using mechanical methods.	Potentially implementable process option.	Yes
		Pneumatic Excavation (Vacuum Extraction/ Pumping)	Vermiculite containing building materials would be removed using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	Potentially implementable process option.	Yes
	Transport	Mechanical Transport (Hauling/Conveying)	Vermiculite containing building materials would be transported by truck or other mechanical conveyance method to disposal site.	Potentially implementable process option.	Yes
		Hydraulic Transport (Slurry Pumping)	Vermiculite containing building materials would be transported in slurry form using a pipeline or other hydraulic conveyance system to disposal site.	Potentially implementable process option.	Yes
		Pneumatic Transport (Vacuum Extraction/ Pumping)	Vermiculite containing building materials would be transported using vacuum hoses, vacuum trucks, or other pneumatic conveyance system to disposal site.	Potentially implementable process option.	Yes

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Table 4-1b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
	Disposal	Landfill Disposal	Removed vermiculite containing building materials would be disposed of at a landfill facility authorized for disposal of asbestos.	Potentially implementable process option.	Yes
		Mine Disposal	Removed vermiculite containing building materials would be disposed of at the Former Libby Asbestos Vermiculite Mine.	Potentially implementable process option.	Yes
		Subaqueous Disposal	Removed vermiculite containing building materials would be disposed of within an impoundment or other large body of water.	Potentially implementable process option.	Yes
Treatment	Biological Treatment	Vermiprocess	Worms are employed to convert vermiculite within the building materials into an inert waste material.	Not technically feasible for site application because it has not been specifically demonstrated for large-scale remediation of asbestos in vermiculite containing building materials.	No
	Chemical and/or Physical Treatment	Pozzolan- or Cement-Based Ex Situ Stabilization/Solidification	Removed vermiculite containing building materials would be mixed ex situ with a pozzolan- or cement-based binding agent before disposal.	Potentially implementable process option.	Yes
		Pozzolan- or Cement-Based In Situ Stabilization/Solidification	Vermiculite containing building materials would be mixed in situ with a pozzolan- or cement-based binding agent.	Not technically feasible for application because it has not been specifically identified or demonstrated for remediation of in situ vermiculite containing building materials. In addition, application of the technology may result in potential impacts to integrity and stability of an intact structure.	No
		Physical Separation/ Segregation	Vermiculite containing building materials would be separated and segregated from uncontaminated insulation and debris for disposal and/or treatment.	Potentially implementable process option.	Yes
		Size Reduction	Vermiculite containing building materials would be reduced in size using approved techniques to facilitate disposal and/or treatment.	Potentially implementable process option.	Yes
		Chemical Decomposition	Vermiculite containing building materials would be decomposed to an amorphous silica suspension at relatively low temperatures (~100°C) using chemicals tailored to the waste stream. The resulting amorphous silica would then be solidified for disposal as an inert waste. ABCOV™ is a demonstrated form of this technology.	Potentially implementable process option.	Yes

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Table 4-1b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Treatment – Continued	Chemical and/or Physical Treatment – Continued	Chemical Digestion	Vermiculite containing building materials would be treated using a spray-applied foam that soaks into porous materials and converts asbestos contained within to an inert, non-fibrous form. DMA® is a commercial form of this technology.	Not technically feasible for site application because the technology has only been demonstrated to affect chrysotile asbestos-containing porous materials that can readily absorb the digestion agent and has not been specifically identified or demonstrated to affect amphibole asbestos.	No
	Thermal Treatment	In Situ Vitrification	An electrical current would be passed between electrodes inserted into in-place vermiculite containing building materials to cause melting. The melted matrix is then allowed to cool in place into a solid vitrified glass mass.	Not technically feasible for application because it has not been specifically identified or demonstrated for remediation of in situ vermiculite containing building materials. In addition, application of the technology may result in potential impacts to integrity and stability of an intact structure.	No
		Electric Arc Vitrification (Ex Situ)	An electrical current would be passed between electrodes in a furnace creating an electrical arc. Vermiculite containing building materials placed in the furnace form a molten bath that cools to form a vitrified glass mass. The vitrified glass mass is an inert waste.	Potentially implementable process option.	Yes
		Plasma Arc Vitrification (Ex Situ)	An electrical current would be passed between electrodes to form plasma. Vermiculite containing building materials placed in the plasma arc form a molten bath that cools to form a vitrified glass mass. The vitrified glass mass is an inert waste.	Potentially implementable process option.	Yes
		Incineration (Ex Situ)	Vermiculite containing building materials would be crushed and mixed. The mixture is subjected to incineration without chemical additives. The reaction product is an inert waste.	Not technically feasible for site application because it has not been specifically identified or demonstrated for remediation of LA asbestos in vermiculite containing building materials.	No
	Thermal/Chemical Treatment	Thermo-Caustic Dissolution	Vermiculite containing building materials would be placed into a high temperature caustic (strong basic) solution. Asbestos fibers are partially to fully converted (changed to an amorphous structure) during immersion. Partially converted asbestos fibers are further converted using chemical reactions to form a viscous mixture, which is later vitrified. The resulting reaction product (glass) is an amorphous inert waste.	Potentially implementable process option.	Yes

Comment [glh1]: CDM Smith still needs to confirm that DMA does not affect amphibole asbestos.

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Table 4-1b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Screening Comments	Retained
Treatment – Continued	Thermal/Chemical Treatment – Continued	Thermo-Chemical Treatment	Vermiculite containing building materials would be shredded and then mixed with proprietary fluxing agents. The mixture is then heated in a rotary hearth furnace. This process is similar to vitrification but does not involve complete melting. The presence of the fluxing agents at elevated temperatures results in remineralization of asbestos fibers. The fibers are converted into non-asbestos minerals such as diopside, olivine and glass.	Potentially implementable process option.	Yes

Notes:

1. The screening process for technical implementability involves a qualitative assessment of the degree to which process options address evaluation criteria presented in Section 4.5.
2. Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of technical implementability. Remaining (unshaded) remedial technologies/process options have been retained for additional screening in Table 4-2b.

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Table 4-2a
Screening of Potentially Applicable Remedial Technologies/Process Options Based on Effectiveness, Implementability, and Relative Cost
Contaminated Soil

General Response Actions	Remedial Technology	Process Option	Description of Option		Effectiveness		Implementability	Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
No Action	None	None	No action would be taken. Contaminated soil would remain in its existing condition.	F	No protection of human health or the environment and no compliance with ARARs.	F	Easily implemented technically but has low administrative feasibility because it is not acceptable to regulatory agencies and does not meet ARARs.	⓿	⓿	Retained (NCP requirement)	Required by NCP as stand-alone alternative.
Monitoring	Inspection	Non-Intrusive Visual Inspection	A non-intrusive (surficial) visual inspection of the immediate ground surface to determine the presence or absence of indicators for Libby Amphibole (LA) asbestos contamination, such as vermiculite, within contaminated soil.	D	Protects human receptors by monitoring contaminant concentrations and migration. Does not directly affect receptors and does not physically address contaminants.	A	Easily implemented using available technical labor resources.	$	⓿	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
		Intrusive Visual Inspection	An intrusive visual inspection of the subsurface (using excavations or boreholes) to determine the presence or absence of indicators for LA asbestos contamination, such as vermiculite, within contaminated soil.	D	Protects human receptors by monitoring contaminant concentrations and migration. Does not directly affect receptors and does not physically address contaminants.	A	Easily implemented using available technical labor resources.	$$	⓿	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
	Sampling and Analysis	Sample Collection and Microscopic Analysis	Air and/or soil samples would be collected for microscopic analysis in a laboratory to determine the potential presence of LA asbestos fibers. Types of samples collected include but are not limited to soil, ambient air, and ABS. Types of microscopic analyses include but are not limited to PLM, stereomicroscopy, and TEM.	D	Protects human receptors by monitoring contaminant concentrations and migration. Does not directly affect receptors and does not physically address contaminants.	A	Easily implemented using available technical labor and equipment resources.	$$$	⓿	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
Administrative Controls	Institutional Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with contaminated soil would be controlled through legal instruments. Examples of governmental (state or local) controls include but are not limited to zoning restrictions, permits, codes, statutes, regulations, and ordinances. Examples of proprietary controls include but are not limited to instruments such as easements and covenants. Examples of informational devices include but are not limited to state registries of contaminated properties, deed notices, and advisories.	C	Restricts future uses of the site that are not protective of human health and the environment but does not physically address contamination.	C	Implemented using legal instruments and labor resources; potential public resistance to certain types of IC instruments.	$$	$	Retained	Potentially viable process option for combination with access controls or contaminated soil containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
	Community Awareness Activities	Information and Education Programs	Community information and education programs would be undertaken to enhance awareness of potential hazards and remedies for contaminated soil. An example of a community information and education program includes the Environmental Resource Specialist (ERS) program.	C	Protects human receptors by enhancing awareness of potential site hazards and remedies. Does not directly affect ecological receptors and does not physically address contamination.	A	Easily implemented using available technical and community involvement labor resources.	$	$	Retained	Potentially viable process option for combination with all other technologies.
		Notification Programs	Notification programs would be undertaken to inform the community of potential hazards from contaminated soil at specific locations. Examples of notification programs include the "U-Dig" system typically used for utility location.	C	Protects human receptors by enhancing awareness of potential site hazards and remedies. Does not directly affect ecological receptors and does not physically address contamination.	A	Easily implemented using available technical and community involvement labor resources.	$	$	Retained	Potentially viable process option for combination with all other technologies.

Comment [glh1]: CDM Smith to confirm after receipt of final draft ARARs from EPA

Table 4-2a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option		Effectiveness		Implementability	Relative Cost		Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
								Capital Cost	O&M Cost		
Access Controls	Access Restrictions	Fencing and/or Posted Warnings	Contaminated soil would be enclosed by fences and warning signs to control access by human receptors and some ecological receptors.	C	Protects human receptors through warnings and restricted access through fencing though human receptors may choose to ignore warnings and circumvent fencing. Does not directly affect many types of ecological receptors that can circumvent fencing.	A	Easily implemented and resources readily available.	$$	$	Retained	Potentially viable process option for combination with administrative controls or contaminated soil containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
Relocation	Temporary Relocation	Temporary Relocation of Residents	Residents would be temporarily relocated to minimize exposure to LA asbestos during implementation of other GRAs.	C	Protects human receptors through temporary relocation during implementation of the response action. Does not directly affect receptors and does not physically address contamination.	C	Implemented during previous response actions on a case by case basis; however potential public resistance and logisitical difficulties for large-scale temporary relocation.	$$$	0	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with contaminated soil removal, disposal, and/or treatment technologies.
	Permanent Relocation	Permanent Relocation of Residents	Residents would be permanently relocated to eliminate exposure to LA asbestos.	A	Protects human receptors through permanent relocation. Does not directly affect receptors and does not physically address contamination.	D	Has not been implemented during previous response actions; high potential for public resistance and logisitical difficulties for large-scale permanent relocation.	$$$$$	0	Retained	Potentially viable process option as a stand-alone approach or for combination with administrative controls or contaminated soil containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
Containment	Surface Source Controls	Water-Based Suppression	Contaminated soil would be kept "adequately wet" using water or a water-based dust suppressant to control airborne migration of LA asbestos fibers from contaminated soil to the surrounding environment.	C	Wetting contaminated soil for dust suppression inhibits asbestos fiber transport by air, but frequent wetting may facilitate asbestos transport through surface runoff. Does not provide long-term effectiveness without continuous re-application.	B	Easily implemented and construction resources readily available. A suitable water supply must be located. Requires continuous re-application to ensure protectiveness.	$$	$$	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with contaminated soil removal, disposal, and/or treatment technologies.
		Chemical-Based Suppression	Contaminated soil would be treated with a resinous or petroleum-based chemical dust suppressant to control airborne migration of LA asbestos fibers from contaminated soil to the surrounding environment.	C	Chemically treating contaminated soil inhibits LA fiber transport by air. Does not provide long-term effectiveness without frequent re-application.	C	Implementable and construction resources readily available. May be difficult to ensure uniform application of the chemical suppressant over the contaminated soil. Requires frequent re-application to ensure protectiveness.	$$$	$$$	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with contaminated soil removal, disposal, and/or treatment technologies.
		Negative Pressure Enclosures	Contaminated soils would be enclosed within a temporary structure. The structure would be operated under negative pressure with filtering to control airborne migration of asbestos fibers in dust to the surrounding environment.	C	Enclosing contaminated materials eliminates airborne transport of asbestos fibers and dust outside of the enclosure. Does not provide long-term effectiveness without continuous operation of the filtering system within the enclosure.	F	Implemented using available construction resources; however, special material and labor resources are required to install the enclosure. Difficult to enclose large areas of contaminated materials and areas with surface obstructions. Does not readily allow free movement between the enclosure and outside areas and impart height restrictions. Requires constant O&M to ensure protectiveness.	$$$$	$$$	Implementability, Cost	Eliminated from consideration.
		In Situ Mixing	Contaminated soil would be mixed with underlying uncontaminated soil or fill materials.	F	Reduces future LA asbestos releases from surface soil after implementation; however, there is potential for subsurface contaminated soil or asbestos fibers to migrate back to the surface over time through natural and/or human activities. It does not protect receptors by itself.	D	Implemented using available construction resources. Difficulty may be encountered in homogenizing contaminated soil with underlying soil and depth to bedrock may preclude in situ mixing at some locations. May require re-application over time if subsurface contaminated soil or asbestos fibers migrate to the surface. Must be combined with administrative and access controls.	$$$$	$$	Effectiveness, Cost	Eliminated from consideration.

Table 4-2a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
Containment (continued)	Surface Source Controls (continued)	Soil or Rock Exposure Barrier/Cover	Contaminated soil would be covered with a layer of clean soil or rock with sufficient thickness to eliminate exposure risks to receptors.	**B**	Protects receptors by eliminating surface exposure of contaminants. Prevents contaminated soil erosion and LA asbestos fiber transport by air and water.	**B**	Implemented using available construction resources and materials. Must be combined with administrative and access controls. Requires some maintenance for long-term protectiveness.	$$$	$$	Retained	Viable as a long-term solution.
		Asphalt or Concrete Exposure Barrier/Cover	Contaminated soil would be covered with layers of asphalt or concrete with sufficient thickness to eliminate exposure risks to receptors.	**B**	Protects receptors by eliminating surface exposure of contaminants. Prevents contaminated soil erosion and LA asbestos fiber transport by air and water.	**B**	Implemented using available construction resources and materials. Must be combined with administrative and access controls. Requires some maintenance for long-term protectiveness.	$$$$	$$$	Retained	Viable as a long-term solution.
		Geosynthetic Multi-Layer Exposure Barrier/Cover	Contaminated soil would be covered with geosynthetic material (such as geomembrane or a GCL) along with protective vegetative or rock layers to eliminate exposure risks to receptors.	**B**	Protects receptors by eliminating surface exposure of contaminants. Prevents contaminated soil erosion and LA asbestos fiber transport by air and water.	**F**	Implemented using available construction resources; however, special material and labor resources are required to install the geosynthetic material. Care must be taken during installation to avoid damage to the geosynthetic. Difficult to install in areas with surface obstructions. Must be combined with administrative and access controls. Requires some maintenance for long-term protectiveness.	$$$$$	$$$	Implementability, Cost	Eliminated from consideration.
Removal, Transport, Disposal	Removal	Mechanical Removal (Excavation)	Contaminated soil would be removed using mechanical excavation methods.	**B**	Protects receptors by eliminating future exposure to contaminated soil and migration of LA asbestos fibers after implementation. Must be combined with containment, transport, disposal, and/or treatment technologies.	**C**	Implemented using available construction resources. Must be combined with surface source controls during implementation to provide protection to workers and the environment.	$$$	⓿	Retained	Viable as a long-term solution; must be combined with contaminated soil transport, disposal, and/or treatment technologies.
		Pneumatic Removal (Vacuum Extraction/Pumping)	Contaminated soil would be excavated using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	**B**	Protects receptors by eliminating future exposure to contaminated soil and migration of LA asbestos fibers after implementation. Collection of dust required to protect receptors and the environment from release of asbestos fibers during implementation. Effective in performing removal of small and fine material during excavation. Must be combined with transport, containment, disposal, and/or treatment technologies	**D**	Efficient for soils and gravel or smaller particle sizes; however, filtering and containment of air stream would be required. Only useful for actions in close proximity to disposal locations. High abrasive wear on equipment may occur depending on type of job performed. Grinding or pulverizing of large size contaminated soil and debris transportation would be required and may conflict with ARARs. This concern can be eliminated if used for finer or smaller sized contaminated soil.	$$$	⓿	Retained	Viable as a long-term solution; must be combined with transport, disposal, and/or treatment technologies.
	Transport	Mechanical Transport (Hauling/Conveying)	Contaminated soil would be transported by truck or other mechanical conveyance method.	**C**	Protects receptors by eliminating future exposure to contaminated soil and migration of LA asbestos fibers after implementation. Must be combined with removal, containment, disposal, and/or treatment technologies.	**B**	Easily implemented using available construction resources; efficient for all sizes of materials. Useful for onsite or offsite actions. Must be combined with source controls during implementation to provide protection to workers and the environment.	$$$$	⓿	Retained	Viable as a long-term solution; must be combined with contaminated soil removal, disposal, and/or treatment technologies.

Table 4-2a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option		Effectiveness		Implementability	Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
Removal, Transport, Disposal (continued)	Transport – Continued	Hydraulic Transport (Slurrying)	Contaminated soil would be transported in slurry form using a pipeline or other hydraulic conveyance system.	**C**	Protects receptors by eliminating future exposure to contaminated soil and migration of LA asbestos fibers after implementation, and would keep transported soils containing LA asbestos "adequately wet". However treatment of water used for transport would be required. Must be combined with removal, containment, disposal, and/or treatment technologies.	**F**	Efficient for soil and gravel or smaller particle sizes. Only useful for actions in close proximity to disposal locations and pumping distance is potentially affected by elevation changes. Difficult to transport large size contaminated soil materials or may require higher flow velocities, which can cause more abrasive wear on equipment. Treatment of water used for transport would be required. Grinding or pulverizing of larger size fractions of contaminated soil for hydraulic transportation would be required and may conflict with ARARs. This concern can be eliminated if used for finer or smaller sized contaminated soil.	$$$$	⓿	Implementability	Eliminated from consideration.
		Pneumatic Transport (Vacuum Truck/ Pumping)	Contaminated soil would be transported using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	**C**	Protects receptors by eliminating future exposure to contaminated soil and migration of LA asbestos fibers after implementation. Effective in performing removal of small and fine material during excavation. Must be combined with removal, containment, disposal, and/or treatment technologies.	**D**	Efficient for soil and gravel or smaller particle sizes; however, filtering and containment of air stream would be required. Can be used in a variety of locations with a portable vacuum truck. High abrasive wear on equipment may occur depending on type of job performed. Grinding or pulverizing of larger size fractions for contaminated soil transportation would be required and may conflict with ARARs. This concern can be eliminated if used for finer or smaller sized contaminated soil.	$$$$	⓿	Retained	Viable as a long-term solution; must be combined with contaminated soil removal, disposal, and/or treatment technologies.
	Disposal	Landfill Disposal	Removed contaminated soil would be disposed of at a landfill facility authorized for disposal of asbestos.	**B**	Protects receptors by eliminating exposure to contaminated soil and migration of LA asbestos fibers at original location and provides containment of contaminated soil within an engineered disposal facility. Must be combined with removal, transport, and/or treatment technologies.	**C**	Implemented using available construction resources. Design and approval of landfill disposal facility, if not an existing facility, may be required. Available space at existing landfills limits the amount of soil which can be accepted. Institutional and access controls would also be required. Requires O&M for long-term protectiveness of the landfill disposal facility.	$$$$	$$	Retained	Viable as a long-term solution; must be combined with contaminated soil removal and transport technologies.
		Mine Disposal	Removed contaminated soil would be disposed of at the Former Libby Asbestos Vermiculite Mine.	**B**	Protects receptors by eliminating exposure to contaminated soil and migration of LA asbestos fibers at original location and provides containment of contaminated soil within an engineered disposal facility. Must be combined with removal, transport, and/or treatment technologies.	**B**	Implemented using the Former Libby Asbestos Vermiculite Mine. Disposal at the former mine is administratively acceptable because reclamation of the source material will address contamination at the mine. The former mine is already a contaminated area with plenty of space.	$$	$$	Retained	Viable as a long-term solution; must be combined with contaminated soil removal and transport technologies.
		Subaqueous Disposal	Removed contaminated soil would be disposed of within an impoundment or other large body of water.	**C**	Protects receptors by eliminating exposure to contaminated soil and migration of LA asbestos fibers at original location and provides containment of contaminated soils within an engineered or natural body of water. Must be combined with removal, transport, and/or treatment technologies. Long-term effectiveness is not ensured due to movement of water or changes in water levels without O&M. Administrative controls and access controls would be required to enhance protectiveness.	**F**	Implemented using available construction resources. Approval of subaqueous disposal, especially for an existing impoundment is likely to conflict with ARARs and not be approved. Design and construction of a new dedicated impoundment for subaqueous disposal would be technically challenging due to limited locations for facility siting. Requires O&M for long-term protectiveness of the subaqueous disposal facility.	$$$$	$$	Implementability	Eliminated from consideration.

Table 4-2a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost		Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
								Capital Cost	O&M Cost		
Treatment – Continued	Chemical/Physical Treatment – Continued	Pozzolan- or Cement-Based Ex Situ Stabilization/Solidification	Contaminated soil would be mixed ex situ with a pozzolan- or cement-based binding agent before disposal.	C	Protects receptors by eliminating exposure to LA asbestos and migration of contaminated soil. Effectiveness of stabilization may decrease over time due to development of freeze-thaw cracking. Must be combined with removal, transport, and disposal technologies.	D	Implemented using available construction resources. Difficult to obtain and transport large quantities of binding agent and homogenize binding agent with heterogeneous soil. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during implementation.	$$$$	⓿	Retained	Viable as a long-term solution; must be combined with contaminated soil removal, transport, and treatment technologies.
		Pozzolan- or Cement-Based In Situ Stabilization/Solidification	Contaminated soil would be mixed in situ with a pozzolan- or cement-based binding agent using a deep soil auger mixing/injection technique.	C	Protects receptors by eliminating exposure to LA asbestos and migration of LA. Contaminated soil would be treated in place, which minimizes exposure to receptors and the environment. Effectiveness of stabilization may decrease over time due to development of freeze-thaw cracking.	F	Implemented using available construction resources. Debris piles are scattered over site, which include large quantities of contaminated soil that vary in depth and extent. Difficult to obtain and transport large quantities of binding agent and homogenize binding agent with vermiculite debris and soil. Depth to bedrock may preclude in situ mixing at some locations.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.
		Chemical Decomposition	LA asbestos contaminated soil would be decomposed to an amorphous silica suspension at relatively low temperatures (~100°C) using chemicals tailored to the waste stream. The resulting amorphous silica would then be solidified for disposal as an inert waste. ABCOV™ is a demonstrated form of this technology.	B	Protects receptors by converting contaminated soil to an inert form. The treatment is irreversible. Once treated, the soil can be used for site restoration. Containment technologies required to protect receptors and the environment from release of asbestos fibers during implementation. Must be combined with removal and transport technologies.	F	Implemented using a patented and demonstrated technology; however, commercialization of the technology is not fully developed. There is only one vendor in the U.S. offering this technology, which requires special chemicals tailored to the waste stream. The treatment process requires physical separation/segregation of contaminated soil into similar materials and associated soil and adjustment of the chemicals for the waste streams. Containment technologies required to protect receptors and the environment from release of asbestos fibers during implementation.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.
	Thermal Treatment	In Situ Vitrification	An electrical current would be passed between electrodes inserted into in-place contaminated soil to cause melting. The melted matrix is then allowed to cool in place into a solid vitrified glass mass.	C	Protects receptors by converting contaminated soil to an inert form. The treatment is irreversible. Contaminated soil would be treated in place, which minimizes exposure to receptors and the environment during implementation. Effectiveness is highly dependent on the nature of the subsurface; heterogeneity of the vermiculite and soil, lack of groundwater, and variable depth to bedrock would impact effectiveness.	F	Implemented using a patented, demonstrated, and commercialized technology. The technology requires a significant, reliable source of electrical power. Difficult to implement since technology is mainly dependent on the electrical conductivity of the subsurface; contaminated soil are highly heterogeneous. Lack of saturated soil in the subsurface hinder the implementation of this technology. Depth to bedrock may also complicate in situ vitrification at some locations. The system requires off-gas treatment system to address air emissions.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.

Comment [glh2]: Need to confirm this is still the case for technologies similar to ABCOV in this catergory due to the time passed since last evaluated

Table 4-2a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option		Effectiveness		Implementability	Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
Treatment – Continued	Thermal Treatment – Continued	Electric Arc Vitrification (Ex Situ)	An electrical current would be passed between electrodes in a furnace creating an electrical arc. Contaminated soil placed in the furnace form a molten bath that cools to form a vitrified glass mass. The vitrified glass mass is an inert waste.	B	Protects receptors by converting contaminated soil to an inert form. The treatment is irreversible. Once treated, the soil can be used for site restoration. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing of contaminated soil. Must be combined with removal and transport technologies.	F	Implemented using a patented, demonstrated, and commercialized technology. However, the literature does not indicate that electric arc furnace units are widely available commercially for remediation of contaminated soil. Thus, contaminated soil would be required to be transported off site for treatment (one demonstration location identified is in New Jersey). Mobilization of a temporary onsite treatment facility is possible but has not been demonstrated in the literature and could pose numerous setup and startup difficulties. The technology requires a significant, reliable source of electrical power. The contaminated soil requires size reduction before it is put in the furnace for vitrification. The system requires off-gas treatment system to address air emissions. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing of contaminated soil.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.
		Plasma Arc Vitrification (Ex Situ)	An electrical current would be passed between electrodes to form plasma. Contaminated soil placed in the plasma arc form a molten bath that cools to form a vitrified glass mass. The vitrified glass mass is an inert waste.	B	Protects receptors by converting contaminated soil to an inert form. The treatment is irreversible. Once treated, the soil can be used for site restoration. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing of contaminated soil. Must be combined with removal and transportation technologies.	F	Implemented using a patented, demonstrated, and commercialized technology. Currently the technology is not available in the U.S. to treat large volumes of contaminated soil. The sole vendor available in the U.S. has commercial portable units, which can only treat very small volumes of contaminated soil. The technology requires a significant, reliable source of electrical power. The contaminated soil requires size reduction before it is put in the furnace for vitrification. The system also requires an off-gas treatment system. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing of contaminated soil.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.
	Thermal/Chemical Treatment	Thermo-Caustic Dissolution	Contaminated soil would be placed into a high temperature caustic (strong basic) solution. Asbestos fibers are partially to fully converted (changed to an amorphous structure) during immersion. Partially converted asbestos fibers are further converted using chemical reactions to form a viscous mixture, which is later vitrified. The resulting reaction product (glass) is an amorphous inert waste.	B	Protects receptors by converting contaminated soil to an inert form. The treatment is irreversible. Once treated, the soil can be used for site restoration. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing of contaminated soil. Must be combined with removal and transport technologies.	F	Implemented using a patented and demonstrated technology jointly developed by the U.S. Department of Energy (DOE) and their contractors for specialized use on DOE facilities. This technology is not commercially available. The high temperature caustic solution poses potential difficulties and risks to workers during the first stage of the process. The contaminated soil requires size reduction before it is put into the caustic solution. The vitrification portion of the technology requires a significant, reliable source of electrical power. The system also requires an off-gas treatment system. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing of contaminated soil.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.

Comment [glh3]: Probably need to confirm this is still true due to the time passed since last evaluated

Comment [glh4]: Need to confirm this is still true due to the time passed since last evaluated

Comment [glh5]: Confirm this is still the case due to the time passed since last evaluated

Table 4-2a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
Treatment – Continued	Thermal/Chemical Treatment – Continued	Thermo-chemical Treatment	Contaminated soil would be mixed with proprietary fluxing agents. The mixture is then heated in a rotary hearth furnace. This process is similar to vitrification but does not involve complete melting. The presence of the fluxing agents at elevated temperatures results in remineralization of asbestos fibers. The fibers are converted into non-asbestos minerals such as diopside, olivine and glass.	B	Protects receptors by converting contaminated soil to an inert form. The treatment is irreversible. Once treated, the soil can be used for site restoration. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during implementation. Must be combined with removal and transport technologies.	D	Implemented using a patented, demonstrated, and commercialized technology (TCCT). Currently the contaminated soil would be required to be transported off site for treatment to the closest operating TCCT facility in Washington State. Mobilization of a temporary onsite treatment facility is possible but with high cost. The contaminated soil requires size reduction before it is put in the furnace for thermo-chemical conversion. The treatment process does not require physical separation/segregation of contaminated soil into similar materials and associated soil. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during implementation.	$$$$$	⓿	Retained	Viable as a long-term solution and meets NCP preference for innovative and demonstrated treatment technologies. Must be combined with contaminated soil removal and transport technologies.

Comment [glh6]: We are going to have to talk to EPA about this technology- previous political/legal issues with vendor

Notes:

1. The screening process for effectiveness, implementability, and relative cost involves a qualitative assessment of the degree to which process options address evaluation criteria presented in Section 4.6.
2. Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of effectiveness, implementability, and/or cost. Remaining (unshaded) remedial technologies/process options have been retained for assembly into remedial action alternatives as discussed in Section 5.0.

Comment [glh7]: Text in progress.

Comment [glh8]: Text will be prepared after EPA concurrence with remedial alternatives identified.

Legend for Qualitative Ratings System: The following ratings were used for evaluation and presentation of effectiveness, implementability, and relative cost:

Effectiveness and Implementability		Relative Cost	
F	None or Low	⓿	None
D	Low to Moderate	$	Low
C	Moderate	$$	Low to Moderate
B	Moderate to High	$$$	Moderate
A	High	$$$$	Moderate to High
		$$$$$	High

Table 4-2b
Screening of Potentially Applicable Remedial Technologies/Process Options Based on Effectiveness, Implementability, and Relative Cost
Vermiculite Containing Building Materials

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
No Action	None	None	No action would be taken. Vermiculite containing building materials would remain in their existing conditions.	F	No protection of human health or the environment and no compliance with ARARs.	F	Easily implemented technically but has low administrative feasibility because it is not acceptable to regulatory agencies and does not meet ARARs	⓿	⓿	Retained (NCP Requirement)	Required by NCP as stand-alone alternative.
Monitoring	Inspection	Non-Intrusive Visual Inspection	A non-intrusive visual inspection of the structure/building to determine the presence or absence of indicators for Libby Amphibole (LA) asbestos contamination, such as vermiculite, within building materials.	D	Protects human receptors by monitoring contaminant concentrations and migration. Does not directly affect receptors and does not physically address contaminants.	A	Easily implemented using available technical labor resources.	$	⓿	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
		Intrusive Visual Inspection	An intrusive visual inspection of the structure/building (using drill and/or scope) to determine the presence or absence of indicators of LA asbestos contamination, such as vermiculite, within building materials.	D	Protects human receptors by monitoring contaminant concentrations and migration. Does not directly affect receptors and does not physically address contaminants.	A	Easily implemented using available technical labor resources.	$$	⓿	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
	Sampling and Analysis	Sample Collection and Microscopic Analysis	Air, dust, and/or bulk building material samples would be collected for microscopic analysis in a laboratory to determine the potential presence of LA asbestos fibers. Types of samples collected include but are not limited to bulk building materials, dust, ambient air, and ABS. Types of microscopic analyses include but are not limited to PLM, stereomicroscopy, and TEM.	D	Protects human receptors by monitoring contaminant concentrations and migration. Does not directly affect receptors and does not physically address contaminants.	A	Easily implemented using available technical labor and equipment resources.	$$$	⓿	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
Administrative Controls	Institutional Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with contaminated soil would be controlled through legal instruments. Examples of governmental (state or local) controls include but are not limited to zoning restrictions, permits, codes, statutes, regulations, and ordinances. Examples of proprietary controls include but are not limited to instruments such as easements and covenants. Examples of informational devices include but are not limited to state registries of contaminated properties, deed notices, and advisories.	C	Restricts future uses of the site that are not protective of human health and the environment but does not physically address contamination.	C	Implemented using legal instruments and labor resources; potential public resistance to certain types of IC instruments.	$$	$	Retained	Potentially viable process option for combination with access controls or vermiculite containing building material containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
	Community Awareness	Information and Education Programs	Community information and education programs would be undertaken to enhance awareness of potential hazards and remedies for contaminated materials. An example of a community information and education program includes the Environmental Resources Specialist (ERS) program.	C	Protects human receptors by enhancing awareness of potential site hazards and remedies. Does not directly affect ecological receptors and does not physically address contamination.	A	Easily implemented using available technical and community involvement labor resources.	$	$	Retained	Potentially viable process option for combination with all other technologies.
		Notification Programs	Notification programs would be undertaken to inform the community of potential hazards from contaminated materials at specified locations. Examples of notification programs include the "U-Dig" system typically used for utility location.	C	Protects human receptors by enhancing awareness of potential site hazards and remedies. Does not directly affect ecological receptors and does not physically address contamination.	A	Easily implemented using available technical and community involvement labor resources.	$	$	Retained	Potentially viable process option for combination with all other technologies.

Comment [glh1]: CDM Smith to confirm after receipt of final draft ARARs from EPA

Table 4-2b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost		Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
								Capital Cost	O&M Cost		
Access Controls	Access Restrictions	Posted Warnings	Warning signs would be used to warn people of dangers posed by vermiculite containing building materials.	C	Protects human receptors through warnings, though human receptors may choose to ignore them. Does not directly affect ecological receptors.	A	Easily implemented and resources readily available.	$$	$	Retained	Potentially viable process option for combination with administrative controls or contaminated soil containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
Relocation	Temporary Relocation	Temporary Relocation of Residents	Residents would be temporarily relocated to minimize exposure to LA asbestos during implementation of other GRAs.	C	Protects human receptors through temporary relocation during implementation of the response action. Does not directly affect receptors and does not physically address contamination.	C	Implemented during previous response actions on a case by case basis; however potential public resistance and logisitical difficulties for large-scale temporary relocation.	$$$$	⓿	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with administrative controls, vermiculite containing building materials containment, and/or disposal technologies.
	Permanent Relocation	Permanent Relocation of Residents	Residents would be permanently relocated to eliminate exposure to LA asbestos.	A	Protects human receptors through permanent relocation. Does not directly affect receptors and does not physically address contamination	D	Has not been implemented during previous response actions; high potential for public resistance and logisitical difficulties for large-scale permanent relocation.	$$$$$	⓿	Retained	Potentially viable process option as a stand-alone approach or for combination with administrative controls or vermiculite containing building materials containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
Containment	Surface Source Controls	Water-Based Suppression	Vermiculite containing building materials would be kept "adequately wet" using water or a water-based dust suppressant to control airborne migration of LA asbestos to the surrounding environment.	C	Wetting vermiculite containing building material for dust suppression inhibitsLA asbestos fiber/ and or dust transport by air, but frequent wetting may facilitate asbestos transport through surface runoff. Does not provide long-term effectiveness without continuous re-application.	C	Easily implemented and construction resources readily available. A suitable water supply must be located. Requires continuous re-application to ensure protectiveness. May have potential impacts to integrity and stability of an intact structure.	$$	$$	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with vermiculite containing building materials removal, disposal, and/or treatment technologies.
		Chemical-Based Suppression	Vermiculite containing building materials would be treated with a resinous or petroleum-based chemical dust suppressant to control airborne migration of LA asbestos fibers from contaminated materials to the surrounding environment.	C	Chemically treating vermiculite containing building materials inhibits LA fiber transport by air and/or dust. Does not provide long-term effectiveness without frequent re-application.	C	Implementable and construction resources readily available. May be difficult to ensure uniform application of the chemical suppressant over the vermiculite containing building materials. Requires frequent re-application to ensure protectiveness.	$$$	$$$	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with vermiculite containing building materials removal, disposal, and/or treatment technologies.
		Encapsulation	Vermiculite containing building materials would be sealed and covered with lightweight high performance coating to prevent the release of asbestos fiber under foreseeable conditions, such as impact, age degradation, or vibration.	B	Protects receptors by eliminating surface exposure of contaminated materials. Prevents LA fiber transport by air.	C	Implemented using available construction resources and materials. Must be combined with institutional and engineered controls. Requires some maintenance for long-term protectiveness.	$$$	$$	Retained	Viable as a long-term solution.
		Negative Pressure Enclosures	Vermiculite containing building materials would be enclosed within a temporary structure. The structure would be operated under negative pressure with filtering to control airborne migration of asbestos fibers in dust to the surrounding environment.	B	Enclosing contaminated materials eliminates airborne transport of asbestos fibers and dust outside of the enclosure. Does not provide long-term effectiveness without continuous operation of the filtering system within the enclosure.	D	Implemented using available construction resources; however, special material and labor resources are required to install the enclosure. Difficult to enclose large areas of contaminated materials. Does not readily allow free movement between the enclosure and outside areas and impart height restrictions. Requires constant O&M to ensure protectiveness.	$$$$	$$$	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with removal and/or treatment technologies

Table 4-2b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
Removal, Transport, Disposal – Continued	Removal	Mechanical Removal	Vermiculite containing building materials would be removed using mechanical methods.	B	Protects receptors by eliminating future exposure to vermiculite containing building materials and migration of LA fibers and dust after implementation. Suppression of dust required to protect receptors and the environment from release of asbestos fibers during implementation. Must be combined with transport, disposal, and/or treatment technologies.	C	Implemented using available construction resources. Must be combined with surface source controls during implementation to provide protection to workers and the environment.	$$$	0	Retained	Viable as a long-term solution; must be combined with transport, disposal, and/or treatment technologies.
		Pneumatic Removed (Vacuum Extraction/ Pumping)	Vermiculite containing building materials would be removed using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	B	Protects receptors by eliminating future exposure to vermiculite containing building materials and migration of LA fibers and dust after implementation. Suppression of dust required to protect receptors and the environment from release of asbestos fibers during implementation Must be combined with transport, disposal, and/or treatment technologies.	C	Efficient for insulation removal; however, filtering and containment of air stream would be required. Can be used in a variety of locations with a portable vacuum truck. High abrasive wear on equipment may occur depending on type of job performed. Grinding or pulverizing of large ACM and debris for pneumatic transport would be required and may conflict with ARARs. This concern can be eliminated if used for finer or smaller building materials or removal of indoor dust.	$$$	0	Retained	Viable as a long-term solution; must be combined with transport, disposal, and/or treatment technologies.
	Transport	Mechanical Transport (Hauling/Conveying)	Removed vermiculite containing building material would be transported by truck or other mechanical conveyance method.	C	Protects receptors by eliminating future exposure to vermiculite containing building material and migration of LA fibers and dust after implementation. Suppression of dust required to protect receptors and the environment from release of asbestos fibers during implementation. Must be combined with removal, containment, disposal, and/or treatment technologies.	B	Easily implemented using available construction resources; efficient for all sizes of materials. Useful for onsite or offsite actions. Must be combined with source controls during implementation to provide protection to workers and the environment.	$$$$	0	Retained	Viable as a long-term solution; must be combined with contaminated materials removal, disposal, and/or treatment technologies.
		Pneumatic Transport (Vacuum Truck/ Pumping)	Vermiculite containing building material would be transported using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	C	Protects receptors by eliminating future exposure to vermiculite containing building materials and migration of LA fibers and dust after implementation. Suppression of dust required to protect receptors and the environment from release of asbestos fibers during implementation. Effective in performing removal of small and fine material during removal. Must be combined with removal, containment, disposal, and/or treatment technologies.	C	Efficient for insulation removal; however, filtering and containment of air stream would be required. Can be used in a variety of locations with a portable vacuum truck High abrasive wear on equipment may occur depending on type of job performed. Grinding or pulverizing of large size building materials and debris transportation would be required and may conflict with ARARs. This concern can be eliminated if used for finer or smaller sized building materials.	$$$$	0	Retained	Viable as a long-term solution; must be combined with contaminated material removal, disposal, and/or treatment technologies.
	Disposal	Landfill Disposal	Removed vermiculite containing building materials would be disposed of at a landfill facility authorized for disposal of asbestos.	B	Protects receptors by eliminating exposure to vermiculite containing building materials and migration of LA fibers at original location and provides containment of contaminated materials within an engineered disposal facility. Must be combined with removal, transport, and/or treatment technologies.	C	Implemented using available construction resources. Design and approval of onsite disposal facility required, if not an existing facility, may be required. Available space at existing landfills limits the amount of materials which can be accepted. Institutional and access controls would also be required. Requires O&M for long-term protectiveness of the onsite disposal facility.	$$$$	$$	Retained	Eliminated from consideration.
		Mine Disposal	Vermiculite containing building materials would be disposed of at the Former Libby Asbestos Vermiculite Mine.	B	Protects receptors by eliminating exposure to vermiculite containing building materials and migration of LA fibers at original location and provides containment of contaminated materials within an engineered disposal facility. Must be combined with removal, transport, and/or treatment technologies.	C	Implemented using the Former Libby Asbestos Vermiculite Mine. Disposal at the former mine is administratively acceptable because reclamation of the source material will address contamination at the mine. However it is not clear to what degree disposal of building materials would be acceptable when compared to contaminated soil. The former mine is already a contaminated area	$$	$$	Retained	Viable as a long-term solution; must be combined with contaminated soil removal and transport technologies.

Table 4-2b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option		Effectiveness		Implementability	Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
							with plenty of space.				
Removal, Transport, Disposal – Continued	Disposal – Continued	Subaqueous Disposal	Removed vermiculite containing building materials would be disposed of within an impoundment or other large body of water.	D	Protects receptors by eliminating exposure to vermiculite containing building materials and migration of LA asbestos fibers at original location and provides containment of vermiculite containing building materials within an engineered or natural body of water. Must be combined with removal, transport, and/or treatment technologies. Long-term effectiveness is not ensured due to movement of water or changes in water levels without O&M. Building materials may tend to float in water, further impacting effectiveness. Administrative controls and access controls would be required to enhance protectiveness.	F	Implemented using available construction resources. Approval of subaqueous disposal, especially for an existing impoundment is likely to conflict with ARARs and not be approved. Design and construction of a new dedicated impoundment for subaqueous disposal would be technically challenging due to limited locations for facility siting. Requires O&M for long-term protectiveness of the subaqueous disposal facility	$$$$	$$	Effectiveness, Implementability	Eliminated from consideration.
Treatment	Chemical/Physical Treatment	Pozzolan- or Cement-Based Ex_Situ Stabilization/Solidification	Vermiculite containing building materials would be mixed ex situ with a pozzolan- or cement-based binding agent before disposal.	C	Protects receptors by binding contaminated materials within a solid inert matrix. Effectiveness of stabilization may decrease over time due to development of freeze-thaw cracking. Must be combined with removal, transport, and disposal technologies.	D	Implemented using available construction resources. Difficult to obtain and transport large quantities of binding agent and homogenize binding agent with heterogeneous vermiculite containing building material. Containment technologies required to protect receptors and the environment from release of asbestos fibers during implementation.	$$$$	0	Retained	Viable as a long-term solution; must be combined with containment, disposal, and/or treatment technologies.
	Chemical/Physical Treatment	Physical Separation/ Segregation	Vermiculite containing building materials would be separated and segregated from uncontaminated insulation and debris for disposal and/or treatment	D	Does not protect receptors by itself; however, separation of vermiculite containing building material from other contaminated materials is required for several treatment technologies. Surface source controls are required to protect receptors from release of asbestos fibers during implementation. Must be combined with removal and/or treatment technologies that require separation of vermiculite containing materials from debris.	C	Implemented using available construction resources but time consuming. Effective in removing large debris, however, there is no proven technology to physically separate vermiculite containing materials from other construction-related materials.	$$$	0	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with containment, disposal, and/or treatment technologies.
		Size Reduction	Vermiculite containing building materials would be reduced in size using approved techniques to facilitate disposal and/or treatment.	D	Does not protect receptors by itself; however, size reduction of larger vermiculite containing building materials is required for several containment, treatment, and/or disposal technologies. Surface source controls are required to protect receptors from release of asbestos fibers during implementation	B	Implemented using available construction resources and approved techniques.Containment technologies required to protect receptors and the environment from release of asbestos fibers during implementation.	$$	0	Retained	Not viable as a long-term solution; however, it is a potentially viable process option for combination with containment, disposal, and/or treatment technologies.
		Chemical Decomposition	Vermiculite containing building materials would be decomposed to an amorphous silica suspension at relatively low temperatures (~100°C) using chemicals tailored to the waste stream. The resulting amorphous silica would then be solidified for disposal as a non-regulated waste.	B	Protects receptors by converting asbestos within contaminated materials to an inert form. The treatment is irreversible. Once treated, the material can be used for site restoration. Containment technologies required to protect receptors and the environment from release of asbestos fibers during implementation. Must be combined with removal and transport technologies.	F	Implemented using a patented and demonstrated technology; however, commercialization of the technology is not fully developed. There is only one vendor in the U.S. offering this technology, which requires special chemicals tailored to the waste stream. The treatment process requires physical separation/segregation of contaminated materials, including vermiculite containing building materials, into similar materials and adjustment of the chemicals for the waste streams. Containment technologies required to protect receptors and the environment from	$$$$$	0	Implementability, Cost	Eliminated from consideration.

Table 4-2b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option		Effectiveness		Implementability	Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
							release of asbestos fibers during implementation.				
Treatment – Continued	Thermal Treatment	Electric Arc Vitrification (Ex Situ)	An electrical current would be passed between electrodes in a furnace creating an electrical arc. Vermiculite containing building materials placed in the furnace form a molten bath that cools to form a vitrified glass mass. The vitrified glass mass is an inert waste.	**B**	Protects receptors by converting asbestos within contaminated materials to an inert form. The treatment is irreversible. Once treated, the material can be used for site restoration. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing. Must be combined with removal and transport technologies.	**F**	Implemented using a patented, demonstrated, and commercialized technology. However, the literature does not indicate that electric arc furnace units are widely available commercially for remediation of contaminated materials. Thus, contaminated materials would be required to be transported off site for treatment (one demonstration location identified is in New Jersey). Mobilization of a temporary onsite treatment facility is possible but has not been demonstrated in the literature and could pose numerous setup and startup difficulties. The technology requires a significant, reliable source of electrical power. The contaminated materials require size reduction before it is put in the furnace for vitrification. The system requires off-gas treatment system to address air emissions. Containment technologies required to protect receptors and the environment from release of LA fibers during initial processing of contaminated materials.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.
		Plasma Arc Vitrification (Ex Situ)	An electrical current would be passed between electrodes to form plasma. Vermiculite containing building materials placed in the plasma arc form a molten bath that cools to form a vitrified glass mass. The vitrified glass mass is an inert waste.	**B**	Protects receptors by converting asbestos within contaminated materials to an inert form. The treatment is irreversible. Once treated, the material can be used for site restoration. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing. Must be combined with removal and transportation technologies.	**F**	Implemented using a patented, demonstrated, and commercialized technology. Currently the technology is not available in the U.S. to treat large volumes of contaminated materials. The sole vendor available in the U.S. has commercial portable units, which can only treat very small volumes of contaminated materials. The technology requires a significant, reliable source of electrical power. The contaminated materials requires size reduction before it is put in the furnace for vitrification. The system also requires an off-gas treatment system. Containment technologies required to protect receptors and the environment from release of LA fibers during initial processing of contaminated materials.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.
	Thermal/Chemical Treatment	Thermo-Caustic Dissolution	Vermiculite containing building materials would be placed into a high temperature caustic (strong basic) solution. Asbestos fibers are partially to fully converted (changed to an amorphous structure) during immersion. Partially converted asbestos fibers are further converted using chemical reactions to form a viscous mixture, which is later vitrified. The resulting reaction product (glass) is an amorphous inert waste.	**B**	Protects receptors by converting vermiculite containing building materials to an inert form. The treatment is irreversible. Once treated, the material can be used for site restoration. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing. Must be combined with removal and transport technologies.	**F**	Implemented using a patented and demonstrated technology jointly developed by the U.S. Department of Energy (DOE) and their contractors for specialized use on DOE facilities. This technology is not commercially available. The high temperature caustic solution poses potential difficulties and risks to workers during the first stage of the process. The vermiculite containing building materials requires size reduction before it is put into the caustic solution. The vitrification portion of the technology requires a significant, reliable source of electrical power. The system also requires an off-gas treatment system. Containment technologies required to protect receptors and the environment from release of LA fibers during initial processing of vermiculite containing building materials.	$$$$$	⓿	Implementability, Cost	Eliminated from consideration.

Table 4-2b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Effectiveness		Implementability		Relative Cost: Capital Cost	Relative Cost: O&M Cost	Reasons for Elimination of Process Option from Consideration	Process Option Viability with Respect to Assembly of Remedial Alternatives
Treatment – Continued	Thermal/Chemical Treatment	Thermo-chemical Treatment	Vermiculite containing building materials would be shredded and then mixed with proprietary fluxing agents. The mixture is then heated in a rotary hearth furnace. This process is similar to vitrification but does not involve complete melting. The presence of the fluxing agents at elevated temperatures results in remineralization of asbestos fibers. The fibers are converted into non-asbestos minerals such as diopside, olivine and glass.	B	Protects receptors by converting vermiculite containing building materials to an inert form. The treatment is irreversible. Once treated, the inert material can be used for site restoration. Containment technologies required to protect receptors and the environment from release of LA asbestos fibers during initial processing Must be combined with removal and transport technologies. Offsite transportation of vermiculite containing building materials could negatively impact the community.	D	Implemented using a patented, demonstrated, and commercialized technology. Currently the vermiculite containing building materials would be required to be transported off site for treatment. Mobilization of a temporary onsite treatment facility is possible but with high cost. The vermiculite containing building materials requires size reduction before it is put in the furnace for thermo-chemical conversion. The treatment process does not require physical separation/segregation of vermiculite containing building materials into similar materials. Containment technologies required to protect receptors and the environment from release of asbestos fibers during implementation.	$$$$$	⓿	Retained	Viable as a long-term solution and meets NCP preference for innovative and demonstrated treatment technologies. Must be combined with removal and transport technologies.

Notes:

1. The screening process for effectiveness, implementability, and relative cost involves a qualitative assessment of the degree to which process options address evaluation criteria presented in Section 4.6.
2. Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of effectiveness, implementability, and/or cost. Remaining (unshaded) remedial technologies/process options have been retained for assembly into remedial action alternatives as discussed in Section 5.0.

Comment [glh2]: Text in progress.

Comment [glh3]: Text will be prepared after EPA concurrence with remedial alternatives identified.

Legend for Qualitative Ratings System: The following ratings were used for evaluation and presentation of effectiveness, implementability, and relative cost:

Effectiveness and Implementability

F	**None or Low**
D	**Low to Moderate**
C	**Moderate**
B	**Moderate to High**
A	**High**

Relative Cost

⓿	**None**
$	**Low**
$$	**Low to Moderate**
$$$	**Moderate**
$$$$	**Moderate to High**
$$$$$	**High**

Table 4-3a
Retained Remedial Technologies/Process Options
Contaminated Soil

General Response Actions	Remedial Technology	Process Option	Description of Option	Process Option Viability with Respect to Assembly of Remedial Alternatives
No Action	None	None	No action would be taken. Contaminated soil would remain in its existing condition.	Required by NCP as stand-alone alternative.
Monitoring	Inspection	Non-Intrusive Visual Inspection	A non-intrusive (surficial) visual inspection of the immediate ground surface to determine the presence or absence of indicators for Libby Amphibole (LA) asbestos contamination, such as vermiculite, within contaminated soil.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
		Intrusive Visual Inspection	An intrusive visual inspection of the subsurface (using excavations or boreholes) to determine the presence or absence of indicators for LA asbestos contamination, such as vermiculite, within contaminated soil.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
	Sampling and Analysis	Sample Collection and Microscopic Analysis	Air and/or soil samples would be collected for microscopic analysis in a laboratory to determine the potential presence of LA asbestos fibers. Types of samples collected include but are not limited to soil, ambient air, and ABS. Types of microscopic analyses include but are not limited to PLM, stereomicroscopy, and TEM.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
Administrative Controls	Institutional Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with contaminated soil would be controlled through legal instruments. Examples of governmental (state or local) controls include but are not limited to zoning restrictions, permits, codes, statutes, regulations, and ordinances. Examples of proprietary controls include but are not limited to instruments such as easements and covenants. Examples of informational devices include but are not limited to state registries of contaminated properties, deed notices, and advisories.	Potentially viable process option for combination with access controls or contaminated soil containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
	Community Awareness Activities	Information and Education Programs	Community information and education programs would be undertaken to enhance awareness of potential hazards and remedies for contaminated soil. An example of a community information and education program includes the Environmental Resource Specialist (ERS) program.	Potentially viable process option for combination with all other technologies.

Table 4-3a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Process Option Viability with Respect to Assembly of Remedial Alternatives
Administrative Controls – Continued	Community Awareness Activities – Continued	Notification Programs	Notification programs would be undertaken to inform the community of potential hazards from contaminated soil at a specific locations. Examples of notification programs include the "U-Dig" system typically used for utility location.	Potentially viable process option for combination with all other technologies.
Access Controls	Access Restrictions	Fencing and/or Posted Warnings	Contaminated soil would be enclosed by fences and/or warning signs to control access by human receptors and some ecological receptors.	Potentially viable process option for combination with administrative controls or contaminated soil containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
Relocation	Temporary Relocation	Temporary Relocation of Residents	Residents would be temporarily relocated to to minimize exposure to LA asbestos during implementation of other GRAs.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with contaminated soil removal, disposal, and/or treatment technologies.
	Permanent Relocation	Permanent Relocation of Residents	Residents would be permanently relocated to eliminate exposure to LA asbestos.	Potentially viable process option as a stand-alone approach or for combination with administrative controls or contaminated soil containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
Containment	Surface Source Controls	Water-Based Suppression	Contaminated soil would be kept "adequately wet" using water or a water-based dust suppressant to control airborne migration of LA asbestos fibers from contaminated soil to the surrounding environment.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with contaminated soil removal, disposal, and/or treatment technologies.
		Chemical-Based Suppression	Contaminated soil would be treated with a resinous or petroleum-based chemical dust suppressant to control airborne migration of LA asbestos fibers from contaminated soil to the surrounding environment.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with contaminated soil removal, disposal, and/or treatment technologies.
		Soil or Rock Exposure Barrier/Cover	Contaminated soil would be covered with a layer of clean soil or rock with sufficient thickness to eliminate exposure risks to receptors.	Viable as a long-term solution.
		Asphalt or Concrete Exposure Barrier/Cover	Contaminated soil would be covered with layers of asphalt or concrete with sufficient thickness to eliminate exposure risks to receptors.	Viable as a long-term solution.

Table 4-3a (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Process Option Viability with Respect to Assembly of Remedial Alternatives
Removal, Transport, Disposal	Removal	Mechanical Removal (Excavation)	Contaminated soil would be removed using mechanical excavation methods.	Viable as a long-term solution; must be combined with contaminated soil transport, disposal, and/or treatment technologies.
		Pneumatic Excavation (Vacuum Extraction/Pumping)	Contaminated soil would be excavated using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	Viable as a long-term solution; must be combined with contaminated soil transport, disposal, and/or treatment technologies.
	Transport	Mechanical Transport (Hauling/Conveying)	Contaminated soil would be transported by truck or other mechanical conveyance method.	Viable as a long-term solution; must be combined with contaminated soil removal, disposal, and/or treatment technologies.
		Pneumatic Transport (Vacuum Truck/ Pumping)	Contaminated soil would be transported using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	Viable as a long-term solution; must be combined with contaminated soil removal, disposal, and/or treatment technologies.
	Disposal	Landfill Disposal	Removed contaminated soil would be disposed of at a landfill facility authorized for disposal of asbestos.	Viable as a long-term solution; must be combined with contaminated soil removal and transport technologies.
		Mined Disposal	Removed contaminated soil would be disposed of at the Former Libby Asbestos Vermiculite Mine.	Viable as a long-term solution; must be combined with contaminated soil removal and transport technologies.
Treatment	Chemical/Physical Treatment	Pozzolan- or Cement-Based Ex Situ Stabilization/Solidification	Contaminated soil would be mixed ex situ with a pozzolan- or cement-based binding agent before disposal.	Viable as a long-term solution; must be combined with contaminated soil removal, transport, and treatment technologies.
	Thermal/Chemical Treatment	Thermo-chemical Treatment	Contaminated soil would be mixed with proprietary fluxing agents. The mixture is then heated in a rotary hearth furnace. This process is similar to vitrification but does not involve complete melting. The presence of the fluxing agents at elevated temperatures results in remineralization of asbestos fibers. The fibers are converted into non-asbestos minerals such as diopside, olivine and glass.	Viable as a long-term solution and meets NCP preference for innovative and demonstrated treatment technologies. Must be combined with contaminated soil removal and transport technologies.

Note:

All remedial technologies/process options mentioned above have been retained for assembly into remedial action alternatives as discussed in Section 5.0.

Comment [glh1]: Text will be prepared after EPA concurrence with remedial alternatives identified.

Table 4-3b
Retained Remedial Technologies/Process Options
Vermiculite Containing Building Materials

General Response Actions	Remedial Technology	Process Option	Description of Option	Process Option Viability with Respect to Assembly of Remedial Alternatives
No Action	None	None	No action would be taken. Vermiculite containing building materials would remain in their existing conditions.	Required by NCP as stand-alone alternative.
Monitoring	Inspection	Non-Intrusive Visual Inspection	A non-intrusive visual inspection of the structure/building to determine the presence or absence of indicators for Libby Amphibole (LA) asbestos contamination, such as vermiculite, within building materials.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
		Intrusive Visual Inspection	An intrusive visual inspection of the structure/building (using drill and/or scope) to determine the presence or absence of indicators of LA asbestos contamination, such as vermiculite, within building materials.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
	Sampling and Analysis	Sample Collection and Microscopic Analysis	Air, dust, and/or bulk building material samples would be collected for microscopic analysis in a laboratory to determine the potential presence of LA asbestos fibers. Types of samples collected include but are not limited to bulk building materials, dust, ambient air, and ABS. Types of microscopic analyses include but are not limited to PLM, stereomicroscopy, and TEM.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with all other technologies.
Administrative Controls	Institutional Controls	Governmental Controls, Proprietary Controls, and Informational Devices	Contact with contaminated soil would be controlled through legal instruments. Examples of governmental (state or local) controls include but are not limited to zoning restrictions, permits, codes, statutes, regulations, and ordinances. Examples of proprietary controls include but are not limited to instruments such as easements and covenants. Examples of informational devices include but are not limited to state registries of contaminated properties, deed notices, and advisories.	Potentially viable process option for combination with access controls or vermiculite containing building material containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
	Community Awareness	Information and Education Programs	Community information and education programs would be undertaken to enhance awareness of potential hazards and remedies for contaminated soil.	Potentially viable process option for combination with all other technologies.
		Notification Programs	Notification programs would be undertaken to inform the community of potential hazards from contaminated materials at specified locations. Examples of notification programs include the "U-Dig" system typically used for utility location.	Potentially viable process option for combination with all other technologies
Access Controls	Access Restrictions	Posted Warnings	Warning signs would be used to warn people of dangers posed by vermiculite containing building materials.	

Table 4-3b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Process Option Viability with Respect to Assembly of Remedial Alternatives
Relocation	Temporary Relocation	Temporary Relocation of Residents	Residents would be temporarily relocated to minimize exposure to LA asbestos during implementation of other GRAs.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with administrative controls, vermiculite containing building materials containment, and/or disposal technologies.
	Permanent Relocation	Permanent Relocation of Residents	Residents would be permanently relocated to eliminate exposure to LA asbestos.	Potentially viable process option as a stand-alone approach or for combination with administrative controls or vermiculite containing building materials containment and/or disposal technologies in which wastes posing a threat to receptors are left on site.
Containment	Surface Source Controls	Water-Based Suppression	Vermiculite containing building materials would be kept "adequately wet" using water or a water-based dust suppressant to control airborne migration of LA asbestos to the surrounding environment.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with vermiculite containing building materials removal, disposal, and/or treatment technologies.
		Chemical-Based Suppression	Vermiculite containing building materials would be treated with a resinous or petroleum-based chemical dust suppressant to control airborne migration of LA asbestos fibers from contaminated materials to the surrounding environment.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with vermiculite containing building materials removal, disposal, and/or treatment technologies.
		Encapsulation	Vermiculite containing building materials would be sealed and covered with high performance coating to prevent the release of asbestos fiber under foreseeable conditions, such as impact, age degradation, or vibration.	Viable as a long-term solution.
		Negative Pressure Enclosures	Vermiculite containing building materials would be enclosed within a temporary structure. The structure would be operated under negative pressure with filtering to control airborne migration of asbestos fibers in dust to the surrounding environment.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with removal and/or treatment technologies.
Removal, Transport, Disposal	Removal	Mechanical Removal	Vermiculite containing building materials would be removed using mechanical methods	Viable as a long-term solution; must be combined with transport, disposal, and/or treatment technologies.
		Pneumatic Removed (Vacuum Extraction/ Pumping)	Vermiculite containing building materials would be removed using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	Viable as a long-term solution; must be combined with transport, disposal, and/or treatment technologies.

Table 4-3b (continued)

General Response Actions	Remedial Technology	Process Option	Description of Option	Process Option Viability with Respect to Assembly of Remedial Alternatives
Removal, Transport, Disposal – Continued	Transport	Mechanical Transport (Hauling/Conveying)	Removed vermiculite containing building material would be transported by truck or other mechanical conveyance method.	Viable as a long-term solution; must be combined with contaminated materials removal, disposal, and/or treatment technologies.
		Pneumatic Transport (Vacuum Truck/ Pumping)	Vermiculite containing building material would be transported using vacuum hoses, vacuum trucks, or other pneumatic conveyance system.	Viable as a long-term solution; must be combined with contaminated material removal, disposal, and/or treatment technologies.
	Disposal	Landfill Disposal	Removed vermiculite containing building materials would be disposed of at a landfill facility authorized for disposal of asbestos.	Viable as a long-term solution; must be combined with contaminated material and transport technologies.
Removal, Transport, Disposal - Continued	Disposal - Continued	Mine Disposal	Removed vermiculite containing building materials would be disposed of at the Former Libby Asbestos Vermiculite Mine.	Viable as a long-term solution; must be combined with contaminated material and transport technologies.
Treatment	Physical and/or Chemical Treatment	Pozzolan- or Cement-Based Stabilization/Solidification	Vermiculite containing building materials would be mixed ex situ with a pozzolan- or cement-based binding agent before disposal.	Viable as a long-term solution; must be combined with containment, disposal, and/or treatment technologies.
		Physical Separation/ Segregation	Vermiculite containing building materials would be separated and segregated from uncontaminated insulation and debris for disposal and/or treatment.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with containment, disposal, and/or treatment technologies.
		Size Reduction	Vermiculite containing building materials would be reduced in size using approved techniques to facilitate disposal and/or treatment.	Not viable as a long-term solution; however, it is a potentially viable process option for combination with containment, disposal, and/or treatment technologies.
	Thermal/Chemical Treatment	Thermo-chemical Treatment	Vermiculite containing building materials would be shredded and then mixed with proprietary fluxing agents. The mixture is then heated in a rotary hearth furnace. This process is similar to vitrification but does not involve complete melting. The presence of the fluxing agents at elevated temperatures results in remineralization of asbestos fibers. The fibers are converted into non-asbestos minerals such as diopside, olivine and glass.	Viable as a long-term solution and meets NCP preference for innovative and demonstrated treatment technologies. Must be combined with removal and transport technologies.

Note:

All remedial technologies/process options mentioned above have been retained for assembly into remedial action alternatives as discussed in Section 5.0.

Comment [glh1]: Text will be prepared after EPA concurrence with remedial alternatives identified.

Table 5-1a
Remedial Technologies/Process Options Evaluated for Assembly into Alternatives for Contaminated Soil
Libby Asbestos Superfund Site

General Response Actions	Remedial Technology	Process Option	Alternative SO1	Alternative SO2	Alternative SO3	Alternative SO4	Alternative SO5	Alternative SO6	Alternative SO7
No Action	None	None	✓						
Monitoring	Inspection	Non-Intrusive Visual Inspection	✓	✓	✓	✓	✓	✓	✓
		Intrusive Visual Inspection		✓	✓	✓	✓	✓	✓
	Sampling and Analysis	Sample Collection and Microscopic Analysis		✓	✓	✓	✓	✓	✓
Administrative Controls	Institutional Controls	Governmental Controls, Proprietary Controls, and Informational Devices		✓	✓	✓	✓	✓	✓
	Community Awareness Activities	Information and Education Programs		✓	✓	✓	✓	✓	✓
		Notification Programs		✓	✓	✓	✓	✓	✓
Access Controls	Access Restrictions	Fencing and/or Posted Warnings		✓	✓				
Relocation	Temporary Relocation	Temporary Relocation of Residents				✓	✓	✓	✓
	Permanent Relocation	Permanent Relocation of Residents			✓				
Containment	Surface Source Controls	Water-Based Suppression				✓	✓	✓	✓
		Chemical-Based Suppression				✓	✓	✓	✓
		Soil or Rock Exposure Barrier/Cover				✓	✓		
		Asphalt or Concrete Exposure Barrier/Cover				✓	✓		
Removal, Transport, Disposal	Removal	Mechanical Removal (Excavation)					✓	✓	✓
		Pneumatic Excavation (Vacuum Extraction/Pumping)					✓	✓	✓
	Transport	Mechanical Transport (Hauling/Conveying)					✓	✓	✓
		Pneumatic Transport (Vacuum Truck/ Pumping)					✓	✓	✓
	Disposal	Landfill Disposal					✓	✓	
		Mine Disposal					✓	✓	

Table 5-1a (continued)

General Response Actions	Remedial Technology	Process Option	Alternative SO1	Alternative SO2	Alternative SO3	Alternative SO4	Alternative SO5	Alternative SO6	Alternative SO7
Treatment	Chemical/Physical Treatment	Pozzolan- or Cement-Based Stabilization/Solidification							✓
	Thermal/Chemical Treatment	Thermo-chemical Treatment							✓

Notes:

1. Check mark designations indicate that remedial technology/process option could be evaluated as a potential component of the indicated remedial alternative.

2. Shaded boxes indicate the process options are not considered for the remedial alternative(s) in question.

3. Where similar process options have been indicated for the same remedial alternative (such as mechanical transport versus pneumatic transport), the most representative process has been selected for evaluation and costing. However that does not preclude use of the similar alternate processes during implementation of the selected remedy.

4. Descriptions of retained remedial technologies/process options are provided in Table 4-3a. Descriptions of remedial alternatives are provided in Section 5.3.

Comment [glh1]: Text will be prepared after EPA concurrence with remedial alternatives identified.

Alternative SO1: No Action / No Further Action

Alternative SO2: Administrative Controls, Access Controls, and Monitoring

Alternative SO3: Permanent Relocation, Administrative Controls, Access Controls, and Monitoring

Alternative SO4: Capping of Contaminated Soil, Administrative Controls, and Monitoring

Alternative SO5: Partial Excavation of Contaminated Soil, Disposal of Excavated Soil at the Former Libby Vermiculite Mine, Capping of Remaining Contaminated Soil, Administrative Controls, and Monitoring

Alternative SO6: Excavation of Contaminated Soil, Disposal of Excavated Soil at the Former Libby Vermiculite Mine, Administrative Controls, and Monitoring

Alternative SO7: Excavation of Contaminated Soil, Thermal/Chemical/Physical Treatment of Excavated Soil, Administrative Controls, and Monitoring

Table 5-1b
Remedial Technologies/Process Options Evaluated for Assembly into Alternatives for Vermiculite Containing Building Materials
Libby Asbestos Superfund Site

General Response Actions	Remedial Technology	Process Option	Alternative BM1	Alternative BM2	Alternative BM3	Alternative BM4	Alternative BM5	Alternative BM6	Alternative BM7
No Action	None	None	✓						
Monitoring	Inspection	Non-Intrusive Visual Inspection	✓	✓	✓	✓	✓	✓	✓
		Intrusive Visual Inspection		✓	✓	✓	✓	✓	✓
	Sampling and Analysis	Sample Collection and Microscopic Analysis		✓	✓	✓	✓	✓	✓
Administrative Controls	Institutional Controls	Governmental Controls, Proprietary Controls, and Informational Devices		✓	✓	✓	✓	✓	✓
	Community Awareness	Information and Education Programs		✓	✓	✓	✓	✓	✓
		Notification Programs		✓	✓	✓	✓	✓	✓
Access Controls	Access Restrictions	Posted Warnings			✓				
Relocation	Temporary Relocation	Temporary Relocation of Residents		✓		✓	✓	✓	✓
	Permanent Relocation	Permanent Relocation of Residents			✓				
Containment	Surface Source Controls	Water-Based Suppression		✓		✓	✓	✓	✓
		Chemical-Based Suppression		✓		✓	✓	✓	✓
		Encapsulation				✓	✓		
		Negative Pressure Enclosures		✓		✓	✓	✓	✓
Removal, Transport, Disposal	Removal	Mechanical Removal					✓	✓	✓
		Pneumatic Removal (Vacuum Extraction / Pumping)		✓		✓	✓	✓	✓
	Transport	Mechanical Transport (Hauling/Conveying)					✓	✓	✓
		Pneumatic Transport (Vacuum Truck/ Pumping)		✓		✓	✓	✓	✓
	Disposal	Landfill Disposal				✓	✓	✓	✓
		Mine Disposal				✓	✓	✓	

Table 5-1b (continued)

General Response Actions	Remedial Technology	Process Option	Alternative BM1	Alternative BM2	Alternative BM3	Alternative BM4	Alternative BM5	Alternative BM6	Alternative BM7
Treatment	Physical and/or Chemical Treatment	Pozzolan- or Cement-Based Stabilization/Solidification							✓
		Physical Separation/ Segregation					✓	✓	✓
		Size Reduction					✓	✓	✓
	Thermal/Chemical Treatment	Thermo-chemical Treatment							✓

Notes:

1. Check mark designations indicate that remedial technology/process option could be evaluated as a potential component of the indicated remedial alternative.

2. Shaded boxes indicate the process options are not considered for the remedial alternative(s) in question.

3. Where similar process options have been indicated for the same remedial alternative (such as mechanical transport versus pneumatic transport), the most representative process has been selected for evaluation and costing. However that does not preclude use of the similar alternate processes during implementation of the selected remedy.

4. Descriptions of retained remedial technologies/process options are provided in Table 4-3b. Descriptions of remedial alternatives are provided in Section 5.3.

Comment [glh1]: Text will be prepared after EPA concurrence with remedial alternatives identified.

Alternative BM1: No Action / No Further Action

Alternative BM2: Interior Cleaning, Administrative Controls, and Monitoring

Alternative BM3: Permanent Relocation, Administrative Controls, Access Controls, and Monitoring

Alternative BM4: Encapsulation of Contaminated Building Materials, Interior Cleaning, Administrative Controls, and Monitoring

Alternative BM5: Partial Removal of Contaminated Building Materials, Disposal of Removed Materials at an Existing Permitted Facility, Encapsulation of Remaining Contaminated Building Materials, Interior Cleaning, Administrative Controls, and Monitoring

Alternative BM6: Removal of Contaminated Building Materials, Disposal of Removed Materials at an Existing Permitted Facility, Interior Cleaning, Administrative Controls, and Monitoring

Alternative BM7: Removal of Contaminated Building Materials, Thermal/Chemical/Physical Treatment of Removed Materials, Interior Cleaning, Administrative Controls, and Monitoring